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HEADQUARTERS OF THE SOCIETY

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A LETTER TO THE SECRETARY

October 8, 1934

Dear Secretary Bishop:

I have been greatly concerned about the . . . Section of the S. P. E. E. Last year interest was dead. The depression had struck this section so hard that all interests outside the political were numb. There are now signs of returning sensation, not because the depression is any less severe but because a spirit-of-help-one's-self is emerging. The depression here is much worse than it was a year ago. But the engineering professors are beginning to realize that if engineering education in . . . is going to get in on the ground floor when the new day does arrive, it will be because the men interested in engineering here do something for the profession now. While they are pulling in their belts they can pull them in just a little bit tighter and build for the future of the profession. For it is out of that future that they will draw their own personal dividends. But for the present personal dividends are the last thing they can afford to worry about. They thought the prospects could never be worse than they were a year ago. They now realize that the outlook is far darker than then. But this is the difference. They now know that they could be worse than they now are. Such an attitude was inconceivable a year ago. But it is conceivable to-day and it is the starting point for a real drive ahead.

I have no personal future in engineering. I am an Emeritus. . . . These men realize that their chief obligations are to their profession, and, wherever they are, they will work to promote this general interest of the profession. These men have ceased to be mainly concerned about their own personal interests. Such concern would be short-sighted anyway. There are bigger objectives and I believe this situation is impressing this truth upon the minds of all our men in this state. I believe the time is most opportune for a stronger professional interest in engineering in this state than we have ever known before and we are going to strike while the iron is hot.

We are planning for a meeting of the S. P. E. E. section when we can make plans for another year's work and when an appeal for attendance at Atlanta will be timely.

Very sincerely yours,

.....

MACHINE DESIGN CONFERENCE

The Machine Design Conference at the annual meeting of the S. P. E. E. was attended by about 50 members. This was excellent considering the many sessions of pre-convention conferences at the same hour. The two papers listed below were presented. These were interesting, instructive and well presented, and provoked much discussion.

"Advanced Courses in Machine Design," E. S. Ault.

"Measurement of Requisite Abilities for Some Courses in Machine Design," J. R. Connelly.

The special nominating committee composed of W. V. Dunkin (chairman), E. S. Ault and A. M. Dudley presented the following nominations for the Executive Committee of the Machine Design Division of the S. P. E. E. for 1934–1935:

V. M. Faires, A. & M. College of Texas.
C. W. Ham, Univ. of Illinois.
E. MacNaughton, Tufts College.
J. M. Foster, North Carolina State College.
F. L. Eidmann, Columbia University.

Abstracts of the two papers presented at this conference, June 21, 1934, follow.

FRANK L. EIDMANN,
Chairman.

ADVANCED COURSES IN MACHINE DESIGN

BY E. S. AULT

Case School of Applied Science

Allow me to emphasize at the outset that in considering instruction in machine design I place first in importance the sound presentation of fundamental principles. Advance courses should not be developed unless adequate attention has been given to the application of rational methods of analysis to the simple problems of design.

The content of any advanced course is dependent upon the motivating intention. A number of reasons for giving advanced work might be proposed, some of which I list as follows:

(*a*) To awaken and develop creative initiative and power of analysis.

(*b*) To emphasize the wide investigation necessary for intelligent design.

(*c*) To show the relationship of design to the factors of manufacture, cost, appearance, salability, and safety.

(*d*) To develop a logical method of solution of an engineering problem by the proper application of scientific knowledge, modified, as necessary, by practical considerations.

(*e*) To give the student a complete foundation of basic principles upon which he might build any design.

(*f*) To develop some particular field because of special interests.

The best method of giving the student a foundation upon which he might build any design is that of giving him instruction in the sciences upon which Machine Design is most dependent. At this time we can select and prepare the tools which will be used later to fashion ideas into concrete, working assemblies. First among these would be a study of stress distribution, both by the application of the theory of elasticity and experimental methods of determining stress, such as photoelasticity. The present need for high strength with light weight and the possibility of failure of the material due to reversal of stresses below the elastic limit make a knowledge of stress distribution and stress concentration more important than ever before. The problems of high speed machinery, such as balancing of rotating and reciprocating masses, critical speeds, vibration and its isolation, inertia forces as found directly and by the use of Corliosis' law, constitute a whole range of subjects. The selection of proper materials with attention to their many properties and the manufacturing processes available should receive more thought than is usually given in college courses.

Taking into account your particular idea of the function of an advanced course, the previous training of the student, the training and interest of the instructor, and the particular circumstances of the location and period you can fix upon a particular type of course and present it in a manner that you prefer. Below are listed courses that are being given at present or are proposed: (1) Design and detail completely some usual machine; (2) design some special purpose machine; (3) redesign some special machine to fulfill some certain requirement; (4) course in material selection-sources, processes, characteristics, and uses; (5) dynamics and kinematics of machines; (6) vibration; (7) lubrication; (8) advanced strength of materials; (9) special stress analysis; (10) study of some special topic—such as gears; (11) laboratory work of an advanced nature—for instance, a complete force and friction analysis of a machine made both analytically and experimentally.

The courses most frequently given in representative schools are (*a*) design of a complete machine, (*b*) advanced kinematics and

dynamics of machines, and (*c*) vibration. The courses thought most desirable by representative teachers of Machine Design are vibrations, advanced stress analysis, and subjects allied to design.

The method of presentation of the course must be adapted to the circumstances of the topic, institution, and the individuals. No one method is the only right one. Special problems assigned to a few individuals might be solved by the student on his own initiative, guided by faculty advice. Small classes studying a formal subject might use the seminar method in which one student is responsible for the preparation and presentation of a particular topic. Certain use might be made of contact with a number of men from industry who would be capable of transmitting a practical attitude towards design. Laboratory investigation and drawing board development could be combined in varying degrees with any of the above methods. I have purposely omitted any mention of formal lectures by the instructor because I think that it should be avoided when possible.

Having discussed some of the things that might be done I shall end by making definite suggestions for your consideration:

(*a*) Do not give an advanced course unless the elementary Machine Design has been developed rationally.

(*b*) Select your particular course with the special circumstances of environment and individuals in mind.

(*c*) For subject matter consider in order the following: Advanced kinematics and dynamics of machine, advanced stress analysis taught by the design specialist, balancing of rotating and reciprocating masses, vibrations.

(*d*) Allow some selection of these, and supporting subjects for undergraduate selection reserving theory of elasticity and vibrations for graduate instruction.

(*e*) For those specializing in design provide a complete design, including drawing, perhaps as a thesis.

(*f*) For graduate instruction use lectures and recitation sparingly and require the student to prepare considerable material to be presented in seminar form.

The Measurement of Requisite Abilities for Some Courses in Machine Design

By J. R. CONNELLY

Lehigh University

This paper describes a study that originated in a desire to improve instruction in engineering courses. One of the first goals of the study was the determination of specific abilities necessary for

success in a given course. Before there could be an evaluation of the relative importance of various factors and abilities each one had to be identified, measured separately in the individual student and correlated with success in the course. The author set out to devise such tests.

The principles and methods to be described will in the main apply to any specific ability requisite for an engineering course. The particular case of ability in computation is used for purposes of illustration.

Among the factors which make for success in a course in machine design is the ability to compute rapidly and accurately. A student cannot give his whole attention to a problem if his thoughts are distracted by the necessity of thinking out simple computations. It should be seriously considered whether a student should be discouraged from entering a course in machine design until he is a fair computer.

In the past it was assumed that students entering our beginning course in machine design understood basic computations. With this knowledge they could, with a little practice, become fairly adept in the use of the slide rule. When ability on the slide rule did not materialize in the majority of the class within a reasonable time, we endeavored to find out why. An investigation disclosed that a considerable portion of the students could not do what we considered a desirable amount of basic computations on the slide rule. The striking fact was that many of the students were untrained to perform some basic computations by any method whatsoever.

Where should we begin to teach basic computations to these men so deficient in their High School training? How may we know when a person is satisfactorily adept at computation? The need of a standardized test is apparent.

The test described is set up to measure ability in computation. In its present form it consists of a number of parts or sections. Each part is devoted to some particular operation in computation and consists of a series of exercises ranged in order of increasing difficulty. The entire class works on each section for the same length of time. The relative difficulty of each exercise is considered in scoring the exercises. After the test has been given to a great number of students it will be possible to establish norms and standards.

The Pearson correlation coefficient between chance halves of the test when last given was 0.89 with a P.E. of 0.02. Putting these values in the Spearman prophecy formula the coefficient of reliability is 0.94 against 1.00 as perfection. This indicates that the test will give consistent results in the majority of cases when repeated.

The scores on the slide rule test were correlated with (1) hour quiz average in Machine Design, and (2) scores on the Freshman Psychological test. The following correlations were determined by the moment area method:

	r	P.E.
Machine Design and Slide Rule	0.713	0.046
Machine Design and Psych. Test	0.417	0.077
Slide Rule and Psych. Test	0.406	0.077

This furnishes considerable statistical evidence that facility in computation particularly on the slide rule is a requisite ability for Machine Design.

This test may be used in an attempt to dicover causes of individual student difficulty, also to prevent failure by discovering cases of poor ability in computation at the start of the course.

This method of attack may be used to measure any specific requisite ability.

MECHANICAL ENGINEERING CONFERENCE

The Committee on Mechanical Engineering of the Society for the Promotion of Engineering Education had a meeting in connection with the annual meeting of the Society, held at Ithaca. In addition to the members of the Committee, Dean Brigman of the University of Louisville and chairman of the previous committee, was asked to attend and to take part in the formulation of plans for the coming two-year period.

After considerable discussion of the report of the previous committee, and in view of the changed conditions since the publication of the Wickenden Report, the Committee decided that it would be wise to direct its activities during the coming two years toward the carrying out of the recommendations of the previous committee on Mechanical Engineering.

Therefore, the Committee has decided:

A. That the Committee on Mechanical Engineering make a study of the objectives and courses of study in Mechanical Engineering.

It is the plan of the Committee to start work immediately on this study and to make a progress report at the next regular meeting of the Society, to be held in Atlanta. Each member of the Committee has agreed to undertake and supervise the study of some particular phase of the work. In this way it may be possible to complete the proposed study within the next two-year period.

H. B. Dirks, Michigan State College,
A. B. Domonoske, Stanford University,
F. L. Eidmann, Columbia University,
Ben G. Elliott, University of Wisconsin,
F. W. Marquis, Ohio State University,
J. J. Wilmore, Alabama Polytechnic Institute.

Abstract of "Liberalizing the Course in Mechanical Engineering by the Introduction of Electives."

By FRANK L. EIDMANN
Columbia University

The term "liberalizing" in this paper is used in the sense of allowing the student some freedom in the selection of technical electives and options as well as non-technical subjects.

In some colleges and engineering schools the mechanical engi-

neering curriculum is rigidly composed of required subjects, leaving to the student no choice of subjects, either technical or non-technical. I should like to raise for discussion the reasons for this condition, as well as the desirability of the introduction of options and electives.

The options and electives fall into five classes:

I. Non-engineering subjects (fundamental sciences and cultural) which belong in the early part of the course.

II. Cultural or other non-engineering subjects of advanced nature.

III. Advanced or specialized technical subjects within the department of mechanical engineering.

IV. Advanced technical subjects in other departments of the engineering school, *i.e.*, civil, electrical or chemical engineering.

V. Advanced subjects in sciences, *i.e.*, physics, mathematics, chemistry.

The number of available electives will vary with the type and size of college and with the number of years allowed for the course. Thus we would expect a larger number of electives in a large university where six years' work is required for the engineering degree. In this case we usually find the greatest number of electives to be taken in the above mentioned class III, but some also in Classes I, II and IV. For a four year course in a small college essentially of the liberal arts type the selections may have to be made almost entirely from classes I and II. There is much to be said in favor of both these extreme cases.

The following are some of the reasons given for the lack of flexibility of curricula in engineering: (1) It is difficult to find the necessary time for electives in the curriculum. (2) The introduction of options and electives increases the difficulty of arranging schedules. (3) The larger the number of such courses, the heavier will be the teaching loads of the faculty. (4) A large number of electives may result in some small classes, making it advisable not to present a course unless a pre-determined number of students register for it; or certain courses may be given in alternate years. (5) Students are not always qualified to choose their electives intelligently. (6) It is conceivable that members of the faculty may not be qualified by training or professional experience to present certain of the advanced technical subjects that should be offered.

The introduction of electives, on the other hand, enables the student to coördinate his studies to meet his particular requirements from both the cultural and professional viewpoints. At present students who have in mind a definite program of subjects have to shop around among the colleges to find one which offers the subjects which they need. I have known of cases in which stu-

dents have left one college to go to another simply because they could not get the combination of technical subjects which they were convinced they should have. Similarly, many students shun engineering courses because of fixed schedules which are devoted almost entirely to technical subjects and which therefore allow no choice of non-engineering electives.

I am convinced that all of the objections which I have heard against the introduction of options and elective subjects into the mechanical engineering curricula can be overcome unless the institution is very small or woefully understaffed. Even in these instances I am sure that some improvement can be accomplished. Even a four year course can be planned so that the student will have the opportunity of taking a well balanced program of cultural subjects, fundamental sciences, the fundamentals of mechanical engineering, and some technical subjects of the student's choice.

ENGINEERING RESEARCH *

By A. A. POTTER

Dean of Engineering, Purdue University

Railway Research.—The research contributions of Purdue University to railway progress date back to 1891 when the first locomotive testing plant in the world was installed at Lafayette, Indiana. This was brought about through the efforts of the late Dean W. F. M. Goss, who appreciated the importance of the scientific method in the study of railway problems, and who greatly aided the railroads of this country in standardizing and in improving their mechanical equipment. Coöperation between the American railroads and Purdue University has continued since that time, with very few years of interruption, and has involved a great variety of investigations on nine locomotives, car equipment, trucks, rails and physical tests of equipment used by railways. The American railroads have appropriated since 1891 about four (4) million dollars to Purdue University for research.

The locomotive investigations, which involved both laboratory and road tests, included improvement in boiler and engine efficiencies with saturated and superheated steam, coal tests, studies of special economy devices, standardization of locomotive stacks and front ends, improvement in spark arresters, studies of rail pressure on locomotive drivers, and radiation losses of locomotives in road service.

The car equipment investigations involved car wheels, brake shoes, car trucks, car journal lubrication, flat spots on car wheels, and refrigerator cars.

As early as 1896 an investigation was conducted at Purdue University on the atmospheric resistance to the motion of railway trains, by the use of model cars placed in a rectangular wind tunnel.

Among the recent investigations at Purdue University in cooperation with the railroads the following are of particular interest:

The Power Brake investigation which was started in 1925 was the result of the conclusions on Case No. 13528 of the Interstate Commerce Commission. The 100-car air brake test rack at Purdue University was used for the laboratory studies and resulted in the elimination of the so-called Automatic Straight Air brake. The

* Abstracts of some of the papers and discussions presented at the Conference on Engineering Research at the 42d Annual Meeting, S. P. E. E., Cornell University, June, 1934.

laboratory tests were supplemented by road tests with a 150-car test train and were conducted on the Southern Pacific Railway. This investigation was completed in 1931 and has resulted in major improvements in air brake design.

The Draft Gear investigations which were started in 1927 and which have continued since that time have resulted in a standardized test procedure for draft gears, in improved draft gear specifications and in superior draft gear designs for a variety of conditions.

Since 1929 tank car outlets and safety valves have been tested.

Since the fall of 1933 investigations have been carried on to determine the riding characteristics of existing truck springs and to develop means for improving existing friction springs, snubbers, stabilizers and special trucks.

Automatic Train Connector studies have been carried on since 1929 at the request of a joint committee which represents the railroads, the Interstate Commerce Commission and the four train-service brotherhoods.

Materials and Structures.—Purdue University may be listed among the pioneers in concrete research. The studies during recent years in this field were concerned with improvement in the durability of concrete, better designs for road slabs, more effective mixtures and better test methods. The major concrete investigations now under way follow: (The figures in the parenthesis after the title of the project refer to the date the study was started.)

Durability of Concrete as Affected by the Quality of the Aggregate (1931). Freezing, thawing and sodium sulphate tests have been included.

Physical and Mechanical Properties of Special and High Early Strength Cements (1927).

Change in the Length of Concrete with Variations in Moisture Contents (1927).

Physical Properties of Masonry Mortars (1929).

Vibration Effect of the Bond between Concrete and Steel (1930).

Designs and Eccentric Connections in Structural Welding (1930).

Repetitive Tests on Welded Connections (1930).

Mechanics of Welded Joints (1930).

Splice Plate Anchorages (1930).

Impact on Steel Highway Bridges (1930).

Concrete Pressure Pipe (1933). An investigation of a special design of concrete pressure pipe in which the encased steel bars can be tightened. 30, 42, and 60 inch pipes of this design have been investigated.

Physical Properties of Blended Cement compared with Standard Portland Cement (1933).

The researches of Purdue University have also contributed to the development of Rostone, a new building material which is being manufactured from wastes.

Gas Research.—Utilization of Manufactured Gas for residence heating has been investigated in coöperation with the Indiana Gas Association since 1928. This has included studies of gas designed and conversion units. Since 1932 warm air furnaces with gas fuel have been investigated. This research has greatly extended the field of use for gas.

Welding with Manufactured Gas was the subject of a coöperative research with the Utilities Research Commission and resulted in new designs of gas torches.

Electric Transmission.—Corona Losses at Extra High Voltages have been investigated continuously, with only short interruptions, since 1910. Among the recent projects in the field of electric transmission the following are of interest:

Improved Weather Resistant Coatings for Overhead Line Wires was a study undertaken in 1929 in coöperation with the Utilities Research Commission. This has resulted in new specifications which have nearly doubled the life of weatherproof wire.

Delayed Recording of Electric Disturbances investigated also in coöperation with the Utilities Research Commission in 1933, resulting in a new and improved device.

Lightning Protection of Distribution Systems and Transformers was another project in coöperation with the Utilities Research Commission (1928–1932).

Impulse Tests on Solid Dialectrics have been carried on from 1929 to 1931.

A by-product of electric transmission research was the invention of a Cathode-Ray Oscillograph of special design which brought about several coöperative studies of the effect of lightning surges and voltage changes taking place in power transmission.

Television.—The Cathode-Ray Oscillograph mentioned was utilized in developing a practical and inexpensive television receiver. This investigation began in 1929 in coöperation with the Grigsby Grunow Company and is being continued in coöperation with another organization.

Miscellaneous Electrical Projects.—Among these the following may prove of interest.

Development of Highway Traffic Lane markers in coöperation with the Purdue Research Foundation.

Highway Illumination.

Design and construction of a machine for rapid testing of circuit breakers in coöperation with the Duncan Electric Manufacturing Company.

Studies of Galvanized Iron Wire.

Life Tests of Resistance Wires.

High Pressure Steam Generator.—Since 1931 in coöperation with the Babcock and Wilcox Company, the Engineering Foundation, and the American Society of Mechanical Engineers the following studies have been undertaken in the field of high pressure steam generation:

Characteristics of a forced circulation steam generator when operating at pressures of 1,500 to 3,600 pounds per square inch; limitations of automatic control; enthalpy of steam at high pressures and temperatures; and laws of fluid friction of water and steam at high pressures and temperatures. The viscosity of water and of steam at a great range of pressure and temperature is now being investigated.

Automotive Research.—For over fifteen years new information has been supplied through researches on carburetors, pistons, steering gears, tires, spark plugs, and special tests of automobiles, trucks and tractors. The more recent investigations in this field are:

Factors affecting Crankshaft Design.

Supercharging.

Riding Qualities of Road Vehicles. This study was started in 1928 in coöperation with the Society of Automotive Engineers but the results published in Bulletin No. 44 of the Purdue Engineering Experiment Station are due mainly to the encouragement given by the Electric Railway Presidents' Conference Committee. An accelerometer of special design was perfected as were also other instruments to record the movements which take place in a moving vehicle.

Miscellaneous Projects.—Small stokers and pulverized fuel for household heating are now being investigated.

Human fatigue studies have been under way since 1930.

Superheater designs for small boilers are being tested out.

Flow of fluids through orifices has been a research project since 1929.

Investigations of dye intermediates and dyes have been carried on since 1931.

The above is a partial list of the recent and active coöperative projects in the Purdue Engineering Experiment Station and indicates very definitely that engineering colleges can undertake and carry out research projects of great magnitude.

The Purdue Research Foundation, which was established to insure full encouragement and adequate reward for creative work, has during the past three years assumed the responsibility of prosecuting forty-one patent applications in order to protect discoveries made by the staff members of Purdue University.

Reports of expenditures for industrial research indicate that even during the past four years of depression the most progressive industries have been spending one to four per cent of their income to keep ahead of practical applications and to make certain that their products show improvement year by year. No accurate data are available about the contributions industries have made for research to engineering colleges but the total amount expended for such coöperative research is insignificant in comparison with its importance. Numerous cases definitely indicate that engineering colleges can carry on research of great magnitude at a lower cost for the results secured as compared with similar investigations in industrial laboratories. Unfortunately the directors of industrial research laboratories are generally not familiar with the facilities of engineering colleges and do not fully realize that an important by-product of research at educational institutions is a supply of creative leaders for industry. Industry has a clear cut obligation to give greater encouragement to research at engineering colleges in order that a greater number of the engineers of the future may have ability to extend the frontiers of knowledge.

Discussion of "Industry Demands and Engineering Education," L. W. W. Morrow

By C. FRANCIS HARDING, Purdue University

Such criticisms and concrete suggestions as those offered by Mr. Morrow in this paper, particularly on the part of those not immediately associated with technical education but yet familiar with the needs of industry and the shortcomings of its applicants are greatly appreciated.

I am sure that all industrial executives and technical educators will agree with Mr. Morrow in his conclusion that two types of engineers and of engineering training are desirable, particularly in the larger technical colleges. The problem at issue is that of the best method of classifying and training these two types without lowering the standards and prestige of either.

Recent studies of the problem of the possible establishment of a separate course in Engineering Administration at Purdue University resulted in an overwhelming negative vote of the engineering faculty of that institution. This vote favored the present flexible elective courses which are more readily adjustable to the needs of the individual student.

As the result of such studies it is believed that the reaction of the faculty and certainly that of the speaker to certain of the most forceful statements in the paper are as follows:

Social sciences are not formulistic or calculable for the reason that they deal with human actions and emotions. At best they permit only the use of a statistical analysis and at worst they deal with only the social and moral averages of a mob of irrational human beings.

But the engineer, the scientist, and the educator are called upon to apply their scientific methods of analysis and their finite solutions to the *social sciences:* to apply the cool-headed objectiveness whereby they are accustomed to reach quantitative conclusions, and yet they must retain the intelligent emotion that is necessary to motivate all human action.

To this we heartily agree and beg to submit that the *engineering training,* plus such sociological electives as are necessary and applicable to establish the proper contact with the future problems "on location" is the proper solution of such preparation.

The foregoing analysis indicates that the present demands from industry reduce to the possibilities of training 2 types of men: (1) a large number of men with a broad training that includes some fundamental engineering and science to fill the functional positions of a large part of industry; and (2) a small but very highly trained group of technical men who can be developed into technical specialists. . . . Yet in a very few instances have the schools faced these 2 demands honestly in order to satisfy them or refuse them.

The latter sentence we deny at Purdue University unless we be classified among the "very few instances." We recognize both the demands and the indicated proportions of our students available for each group but we submit that individual student analysis and adaptation of sociological and economic electives are preferable to the opening of a necessarily "snap course' into which some of group No. 2 might be tempted to enter to their ultimate sorrow. Better more rigorous training for *several* future executives than superficial training for *one* potential research worker and specialist.

Why not make a new course that incorporates the best elements of both the engineering and arts courses to prepare the large majority of college students for business life and relegate both of the older courses to more highly specialized types of education? . . . It is evident that the present courses in administrative or industrial engineering do not measure up to the requirements and possibilities of the proposed course, although they attempt to do this in some degree. These courses are unsatisfactory because present facilities in engineering and arts are like water and oil. They do not mix. In some instances the economics department dominates and in others the engineering department keeps control.

Again, we submit that the new course is not necessary, at least in our situation. The engineering schools at Purdue University are in the vast majority and there are no colleges of arts, law and medicine. The non-engineering and service departments are deal-

ing primarily with engineering students and naturally assume the engineering method of attack.

The course must be a welded whole and not a composite of courses already given in 2 departments. It must have a content, a method, an administration, and an identity of its own to be successful. It should be a separate college in the typical university organization.

This we believe to be unnecessary at our institution for reasons stated above. The course for *each individual student* should be a "welded whole" but such does not necessarily imply a separate curriculum and college for all.

An essential part of this conception of a technical course is a careful selection of the students and the instructors. They must be high in quality although relatively few in number and their capacities must be measured by technical yardsticks.

To this we heartily subscribe. In fact it is recognized as an endorsement of our *individual student selection* and elective course recommendation adopted for both types of students. The technical yardstick is applied to instructors in other than engineering departments as well.

Some Recent Experiences in Conducting Coöperative Research

By K. W. MILLER

Director, Utilities Research Commission, Chicago

The Utilities Research Commission, Inc., is an organization now supported by the three chief electric and gas utilities operating in the Chicago district. It was formed to undertake technical research problems of interest to its member companies. These operating companies all have their own testing laboratories, but the purpose of the Commission is to act as an agent to place research (or sometimes unusual testing work) for which its sponsor companies have neither staff nor equipment with some outside research laboratory, and to follow up and supervise the work. It acts as a centralizing agency in the collection of funds for this purpose from its member companies and in the distribution of these funds to research agencies (usually universities) chosen to conduct the work. In addition, as a matter of practice the Commission is a convenient means for the sharing of costs on a project of interest to two or more sponsor companies but of a nature permitting its solution locally. In such cases the investigations are placed in the laboratories of one or more of the member companies, although jointly financed through the Commission.

The Commission makes contracts and maintains contacts with the research agencies. Through its committees on individual cases it endeavors to give research investigators the benefit of practical experience. In turn these committees study the reports and data during and at the close of a case and bring these results back to their companies, where the committee members can put into useful effect the practical findings obtained by the investigators.

Started in 1924, the Utilities Research Commission has grown in vigor and scope. It has completed or in progress fifty-three research cases, some of them remarkably successful, and, after incorporation in 1930 for the purpose, is now interested in some dozen patents or application. Because of research projects recently successfully completed at two universities, just now active projects are under way at only one university in addition to sponsor company laboratories; but to date the Commission has placed research projects with seven universities, one commercial laboratory, the Bureau of Standards, and has contributed to researches by four national engineering or research societies. At present investigations are in progress on combustion of city gas (two cases), turbine blade deposits, removal of sulphur dioxide fumes from generating station stack gases, creep of lead cable sheath under tensile stress, X-ray studies of deteriorated insulating oils, air conditioning (contribution to A. S. H. & V. E.), prevention and cure of deterioration of domestic chimney flues having gas-fired furnaces, and three other minor but similar projects.

On account of its organization and facilities the Commission has become a convenient body for miscellaneous functions and staff activities of value to its member companies. In turn it derives from these operating companies in the progress of their individual testing or research, as well as from its contacts with numerous research organizations, information of interest and value to its constituents.

In common with most other organizations, the Utilities Research Commission has not escaped the trying circumstances of the present world-wide depression, but it is felt that having so far successfully weathered these adverse influences is a strong indication of the essential worth of the enterprise.

One matter of vital interest and effect on the universities involved as well as ourselves is our method of financing. Near the end of each calendar year the Commission, through its permanent Program Committee, determines which active cases should be continued through part or all of the next year, which ones dropped, and what new research cases are of value or necessity to the sponsor companies. After careful consultation with interested parties in the companies and in the universities, and approval by the officers of the Commission, the budget drafted by the Program Committee

is submitted at the beginning of the next calendar year for action by the presidents of the sponsor companies. Considering the financial difficulties with which the utility companies have recently been faced, the grants for research have been quite generous, although this year we have only one-quarter the budget for 1930. After receiving approval for calling on the supporting companies for a given total sum during the year, contracts are renewed with the research agencies on continued cases and negotiations started with them on new cases, contracts made, and work begun.

One difficulty of this method of financing and contractual relations with universities is the difference in the fiscal years. We cannot make commitments beyond the end of the calendar year and, especially during the recent period of drastic curtailments, there is a period of uncertainty and anxious waiting on active going cases at which is the very middle period of activity in the school year. It would be ideal to have our contracts coincide with the school year, both for the acquisition of the best talent by the university for the main investigator and in obtaining student help for the lesser and miscellaneous assignments. Also, in many cases, this would permit establishment of fellowships on some particular types of problem with mutual advantage to all parties. However, from our standpoint such an arrangement has not been found feasible. We try to anticipate (and usually do) closing of a case three months in advance and so notify the university that, at the expiration of the contract, it will not be renewed. When for special reasons cases had to be closed unexpectedly at the termination of a contract, it has usually been found possible to extend the work for a few months to allow an orderly termination and fair consideration for the investigators.

Projects for investigation are usually suggested by officers or employes of our sponsor companies, but in a few cases from sources outside the Commission. At present there is a distinct tendency for the projects which are accepted and investigated all to be of local origin and to be of a short-time or "quick turnover" nature with results almost predictable in advance and requiring relatively small financial outlay. Several such projects have been initiated and successfully concluded in the past three years with results amply repaying the expenditure, but it is doubtful whether such projects are attractive to universities because of their short-time nature and the fact that generally their fundamental scientific value is not so great.

There is one noteworthy feature of research that ordinarily is a source of impatience but which is now very acceptable, namely, the time-lag in the maturing of valuable practical results of research. During the last two years the Utilities Research Com-

mission has reaped a rich reward in the successful conclusion of many cases started at various periods up to several years ago—a return far out of proportion to the present scale of financial outlay. This is rather obvious and to be expected. However, it means that when a more normal program or scale of research activity is again resumed, a quickening of pace and shortening of time-lag will be necessary to make research appear as remunerative as it was. This corollary may not be so obvious, but it follows that the universities will have to reckon with a time factor perhaps annoying to many investigators. The only serious objection I have heard leveled against universities as agents for industrial research is their inherent indifference to time.

Another trend which is apparent in the recent experiences and development of the Utilities Research Commission is a shift in attention and energy of the executives of the sponsor companies from technical to financial and managerial problems. Not that they are hostile or even indifferent to technical research—on the contrary, they are very alert to the problems yet unsolved. But, at least for the utilities, with technical problems less urgent and personnel and financial matters very pressing, engineering research as engaged upon by the Commission must now and in the future achieve still greater successes to gain their attention and active support. This means that universities and the research investigators, if interested in cooperating in the solution of our technical problems, must stir themselves to still greater effort and ingenuity in investigation.

One reason which has made universities and their experiment stations attractive agents with us for the placement of research cases has been the flexibility of the arrangement. As soon as a project is proposed and formulated, it is usually possible to find a school well equipped with apparatus and experts proficient in that special line and, with little delay in obtaining additional apparatus and (usually) a full-time investigator for the particular problem, work can be started almost at once. In normal times it was about as simple a matter to terminate a research case, whether successfully completed or obviously hopeless, without working hardship to any party. However, during the most drastic periods of retrenchment there appeared to be an implied obligation to continue a research case or find and substitute a new problem to maintain employment of investigators otherwise turned adrift. Sometimes this was impossible. This releasing of high-grade research workers with no other occupation in sight by the universities which hired them no doubt caused the universities, as well as ourselves, considerable anxiety. In most cases on our projects the men found employment elsewhere; often we were able to assist in their reemployment.

One further matter of current interest to us and I will close. We have been giving considerable thought to policies with respect to patents. Usually our principal concern is to protect ourselves in uncontested use of our own findings. If, in addition, an invention should arise, in the course of investigation on a research case, which would result in some income to offset costs of still more research, such return would be very acceptable. In either case it is rarely in the province of the university, nor has it the facilities, to carry an invention in the engineering field from the laboratory stage to a commercial success through the expensive development stage. At least, for such cases as we now have or have had in the past, this development stage must usually be carried out by some large reputable manufacturing company and of course these companies are reluctant to undertake such a problem without some clearly-defined patent agreement. The different universities have a wide range of various patent policies as outlined in a recent publication.* However, some definite policy, and one making some fair and equitable return to the inventor, the university, and the industry sponsoring the research, should be adopted by any university which desires to obtain and retain the support of industry for research. Procedures such as developed at Michigan, Purdue, and M. I. T. are examples of patent policies well-adapted to our needs.

I have not attempted to point out the mutual advantages to the universities and ourselves of a coöperative procedure in research. These advantages have been adequately summarized in papers before your society and elsewhere. Neither have I undertaken to restate the essential reasons for sponsoring technical research at all —even in these times when amongst many unthinking people research is somewhat discredited. The facts remain unchanged in these matters, are well-known to the informed,† and now are so well-accepted as to be taken for granted. Instead, I have endeavored to show how in these rather trying times our research organization actually functions and what are its problems and activities which may be of interest or concern to yourselves. I have not relieved the argument with a recital of our technical findings or achievements for, though these are extremely varied and interesting, they are not essential to the main discussion.

The Utilities Research Commission has enjoyed and expects to continue to receive the benefit of useful and pleasant contacts with

* "University Patent Policies," by A. M. Palmer, *Journal of the Patent Office Society*, February, 1934.

† See, for example, report of President Roosevelt's Science Advisory Board, Dr. K. T. Compton, Chairman, quoted in the *Science News Letter* for March 3, 1934.

universities on coöperative research projects. This arrangement has proved very successful now and in the past. I have tried to point out a few trends which, in my opinion, indicate that requirements in the future may be a little more rigorous, a little more exacting, but which will improve a practice already demonstrated to be thoroughly sound and mutually profitable.

Student Research and the Four-Year Engineering Curriculum

By THEODORE H. MORGAN

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Engineering curricula of the present day are the result of continuous efforts over many years on the part of our colleges and universities to prepare young men to carry on the advancement of science and engineering, and to supply the engineering profession with men educated and trained for its requirements. The subject perhaps suggests reminiscence and historical development but let me relieve your minds immediately for such is not the plan of this paper. Our society possesses many excellent discourses and reports pointing out all that has led up to the present curriculum situation. For the purpose of this discussion there is no reason why we should not frankly admit existing conditions in our curricula and consider them in view of the requirements of the times and the demands of the future, to the limited extent to which the latter can be determined.

The extraordinarily rapid development of both pure and applied science—setting a pace in the latter part of the nineteenth century which has been carried on to the present day with no apparent slackening—has left an indelible mark upon the objectives of the courses of study in our engineering colleges. The dominating influence has been, and still is, the desire for continued advancement in science and engineering. In our literature and discussions this influence is evidenced by the frequent repetition of the one word—"research." In the field of education progress in science has brought with it a situation presenting new and difficult problems. Before a forward movement can be made from any particular position of scientific accomplishment it becomes necessary to have a thorough understanding of all that has gone before. Constant advancement into new territory has thus always meant a wider field for the student to survey and comprehend. This has resulted in the continual increase of the type of work in our curricula which has for its purpose the bringing of a young man to the point where he has a comprehension of the scientific situation

of his day and time. Such work must of necessity be factual to some extent for one must have an informational background as a basis for reasoning and constructive thinking. In recent years it has been the policy of the more progressive colleges to keep the informative work or the study of purely factual material at a minimum. Nevertheless, there is general agreement that pure and applied science have increased to such an extent that the undertaking by the engineering schools to complete the work of formal education in a brief four years has resulted in over-crowded curricula, with limited time for the development of the thinking powers of the student.

Consideration must also be given to other phases of the subject in order to complete the story of the curriculum situation as we find it today. The common conception of the term "engineering" has broadened rapidly in recent years. In addition to the physical sciences and their application in the engineering field we have a persistent demand for more generalized knowledge. This movement had its beginning when it was first recognized that the industries of our country would have to look for the men who had come along the road of the engineer for the management of their organizations. It now appears that in future the activities of the engineer will embrace not only industrial problems but questions of human relationships and sociologic developments. The importance of such matters is recognized by engineering educators and new influences are being felt in our curricula. As we move toward a broader and more complex goal the preparation for each new advance becomes increasingly difficult. In addition to the need for a wider background of scientific knowledge we have an ever broadening concept of the field of endeavor of the engineer. Such a movement should not be a matter of concern to anyone. It is the natural outcome of the growing importance of engineering. The demands upon the profession are becoming broader. The engineer must have a better understanding of civics, economics and business if he is to take a more important position in the management of our industries, and he must apply the fundamental principles of these subjects with all the faithfulness he has used in applying the laws of the physical sciences to engineering structures. If he is to have more to do with human beings he must know more about human nature and the action of the human mind. The insistent pressure of the times indicates that all these things and more must be woven into the engineering pattern of the future. The idea is most inspiring and it should lose none of its attractiveness on the basis that it implies a departure from science. The late David Starr Jordan explained his broader interpretation of science in words particularly applicable to our present changing conceptions of engineering. He has stated:

Incidentally I assert (*a*) that pure science cannot be separated from applied science—knowledge in action—in which science finds its verification, (*b*) that philosophy—the logic or mathematics of human experience—is an outgrowth of science, and (*c*) that in all matters concerning human conduct science furnishes the final guide or, at least, any guide to thought and action which has proved to be safe becomes by that fact a part of science.

Our original objective has never been abandoned. We still believe as firmly as ever that the salvation of our civilization depends upon continued scientific progress and advancement. The benefits resulting from the spirit of research in our engineering colleges and universities are so far-reaching and of such importance that they cannot be lightly considered or waved aside because of the insistent pressure of other matters. Research is not only absolutely necessary to the progress and maintenance of our civilization, but it has a most important function in the education of a young man who hopes to become worthy of the name "engineer."

As a result of the growth of science and the development of engineering many textbooks have been written which present subjects in perhaps an all too logical and readily understood manner. When accompanied by formal lectures of a similar nature it is conceivable that there may be a decided lack of the stimulation required to excite the student's mind to the effort necessary for its proper development. This danger has been recognized and an attempt made to compensate by extensive experimental courses in well equipped laboratories. However, here also there exists the same danger. The very size of the classes may call for a set of rather standardized experiments. The student realizes that they have been frequently repeated and because of this fact they are less effective in stimulating his thought and awakening his intellectual curiosity.

The undergraduate thesis at its best contributed much to the education of the young engineer. While it was research of a very elementary nature it offered an original problem to the student and thus served as a beginning for his training in such matters. Mental stimulation resulted from the challenge which an unsolved problem presented. The student's negative qualities of initiative and aggressiveness were developed by the demands placed upon them. He was forced to think for himself along original lines and, above all, interest and enthusiasm were kindled by the very nature of the work. It would be difficult to think of any other one thing which could have so many educational advantages. Yet, to-day we find the undergraduate thesis has been generally abandoned for excellent reasons. I wish to make no plea for its re-introduction into the four-year curriculum for that hardly seems advisable under

present conditions. However, the question might be raised as to whether, while permitting it to be gradually crowded out of the picture, we have realized the loss in educational value and have attempted to compensate therefor to the fullest extent possible.

It is believed that there are opportunities in our regular courses to obtain many of the educational benefits which thesis work of a high order at one time provided, if we appreciate the need and definitely work for this purpose. A few remarks concerning senior engineering laboratory work will perhaps illustrate what I have in mind. These courses can be planned, arranged, and offered in such a manner as to be as effective as the undergraduate thesis. In order to accomplish this they must consist of something more than a number of rather standardized experiments fully outlined and described in textbooks or in a specially prepared syllabus. A course of the latter nature is too frequently considered by the student as just another hurdle on the road to graduation. If our courses are to provide the educational advantages previously obtained from a well planned and effectively administered undergraduate thesis project they must embody its essential elements. Sufficient thought and consideration on the part of capable instructors will result in laboratory problems presented to the student in such a manner that he will look upon them as original problems for which he must find original solutions. Textbooks and standard laboratory instructions will prove of little direct help although he should be encouraged to use them in order to obtain a proper background of knowledge. The objection may be raised that such a procedure would necessarily consume so much more of the student's time that he could not cover the field commonly encompassed. This would unquestionably be the case, but a choice must be made. Is it more important to obtain a considerable amount of informational knowledge by rather hastily repeating many standard experiments or is it better for the student to cover a smaller part of the total field while learning how to attack a problem requiring original solution on his part?

It is very true that such a plan cannot be effectively carried out except by a superior instructional staff. It will never be done by those who merely act as filling station attendants doling out a specified amount of informative material per term. The teacher must have the faculty of awakening the student's interest and enthusiasm for finding out things for himself. Success in attacking any problem requires full appreciation that the end justifies the effort and we need instructors who can make the student realize the joy and delight of original thinking. It is not at all necessary that the teacher be a man of outstanding research skill. He must, however, have a keen interest in his subject and the ability to

awaken in his students a like interest and to maintain their enthusiasm. The requirements of the teaching profession today were most aptly stated by Confucius many years ago in the words: "Who keeps the old akindle and adds new knowledge is fitted to be a teacher."

Science has had a phenomenal growth. The conception of engineering and the field embraced have steadily increased. New subjects had been added to our curricula, courses have been revised, abbreviated or dropped; undergraduate research and thesis have been largely abandoned or their effectiveness lost—at all times holding to a course of four years' duration. It is true that in isolated cases attempts have been made to lengthen it but they have met with little or no support from the main body of our institutions. In view of the fact that we are now face to face with the problem of doing something more, not only to make our graduates better engineers but better rounded citizens in a society crying for a new and broader motivation in its citizenry, the length of our curriculum again becomes a live question. However, this matter is outside our present discussion. It is true that a longer engineering course would provide opportunity for more adequate research and thesis work but the four-year course, being general at the present time, can be termed the standard curriculum and as such is the only one with which we are concerned here.

Speaking in broad terms the requirements for our graduates are quite definite. Society and the profession need men with mobile minds, trained and capable, minds which can do rigorous, accurate and constructive thinking upon problems which become increasingly difficult with advancement in engineering and change in economic conditions. From all sides comes the call for men who can assume responsibility and leadership. It is true that no educational institution can hope to graduate many men with such characteristics, but we can endeavor to increase their number and to raise the level of the average.

Changing conditions in the world demand changes in the form of education. This a period when it is generally recognized that engineering education is confronted with many problems of major importance. As we move forward toward their solution may we never lose sight of the great value of the spirit of research and original investigation.

MATHEMATICS CONFERENCE

By R. S. BURINGTON

Case School of Applied Science

Introduction

In 1907 a joint meeting of mathematicians and engineers was held in Chicago under the auspices of the *American Mathematical Society* and *The American Association for the Advancement of Science.* At the suggestion of officers of the *Society for the Promotion of Engineering Education,* a committee under the chairmanship of E. V. Huntington was appointed to submit a report on the teaching of mathematics to students of engineering. This committee prepared a synopsis of fundamental principles and methods of mathematics, which, in their opinion, constituted the minimum mathematics equipment of the student of engineering. This report was accepted by the *Society for the Promotion of Engineering Education* at the Pittsburgh meeting held in 1911 and was subsequently published by the Society under the head *Syllabus of Mathematics.* This syllabus did not concern itself with mathematics beyond elementary calculus. A more exhaustive inquiry was later undertaken by the *International Commission on the Teaching of Mathematics.*

For the past seven years, through its summer schools, the *Society for the Promotion of Engineering Education* has brought together various groups of engineering teachers, together with industrial educational specialists, with a view to the betterment of teaching. The programs have combined a broad survey of content, sources and correlations of subjects, with intensive study of learning processes and teaching methods. The project received wide recognition and its results have been most fruitful.

In the summer of 1931 a summer school was held for teachers of engineering mathematics at the University of Minnesota. Its general purpose was the improvement of the teaching of engineering mathematics. A study was made of course content and teaching problems of engineering mathematics through elementary differential equations.

During the present year a committee of the Society, headed by past President Seaton, has been making a careful study and appraisal of the summer school project, preparatory to making a future plan of action. Pending the committee's report it was

deemed impractical to plan a separate session of the summer school in 1934. However, it was decided to try an experiment of a somewhat different character and one well within the Society's own resources. This experiment consists of a group of conferences, including the Mathematics Conference, as a prelude to the annual convention of the Society.

In October, 1933, at the request of President Wickenden, I prepared a *prospectus* of a proposed mathematics conference to be held at this meeting of the Society. On May 5th, President Wickenden asked me to organize a conference—this conference—to consider the general topic *Mathematics Courses Beyond Elementary Calculus for Engineering Students.*

This subject together with the many related topics that it suggests is unquestionably of increasing interest both from the technical as well as from the educational points of view. It has been the wish of the Mathematics Committee to bring together mathematicians, mathematics teachers, engineers and research people for mutual and constructive discussion of the broader aspects of the problem.

In concerning ourselves with this topic—*Mathematics Courses Beyond Elementary Calculus for Engineering Students*—the question naturally arises "what is elementary mathematics?" What is frequently thought of as elementary may be quite advanced and conversely what is advanced may be quite elementary. I do not propose to go into this particular phase of the topic, but to just *emphasize* the fact that the conference is concerned primarily with those branches of mathematics which are usually studied by engineering students, if at all, after the conventional and quite standardized courses in algebra, trigonometry, analytic geometry, elementary differential and integral calculus.

What type, if any, of mathematics courses might and should be offered for undergraduate and graduate engineering students? Who should take such courses? What type of coördination between mathematics and technical courses is possible and desirable, if any? To what extent, if any, should the teaching of mathematics to engineering students be colored by a spirit of applied science? In other words, must mathematics be taught to engineering students in a different spirit than to non-engineering students? What are the qualifications of a mathematics teacher to engineering students? What do those experienced engineers and research men, who are thoroughly qualified, because of their mathematical and scientific training, and experience, recommend as the type of mathematics training needed by the electrical engineer, the mechanical engineer, the automotive engineer, etc.? What is the significance, both from an educational standpoint, as well as from a technical standpoint,

of the contribution of mathematics to research in fluid motion, chemistry, physics, engineering sciences in general? Should contact of mathematicians in a consulting capacity with industry be encouraged or not? Should any particular type of mathematics research be encouraged at an engineering school on the part of the faculty and the more advanced students? If so, what type of research? Should not the mathematician in pure mathematical research also be encouraged?

A glance at the program will show the manner in which these and allied topics are to be taken up and discussed. It is our hope that engineers and mathematicians, alike, will benefit from the various papers and discussions of this conference and from the new acquaintances they make. We hope that the engineers may gain a better appreciation of the importance and power of mathematics, and the contribution that mathematics has made and will make in the study and development of the physical sciences. We hope that this in turn will be reflected in the manner in which mathematical and engineering studies are conducted; and that this will result in a greater utilization of mathematics in engineering curricula as an aid in the building of a more suitable foundation for later use in technical and research work.

Also, we hope that mathematicians may learn more of the use made of mathematics in the physical sciences. We hope that the mathematicians may learn from the engineer what he considers to be desired in the mathematics training of the engineer, and that thus the mathematicians may be able to interpret more intelligently the engineer's need; and that as a result, his subject will have added vitality *and interest,* both to himself and to his students.

Qualifications and Training of Teachers of Mathematics for Engineers

By J. H. WEAVER

Professor of Mathematics, Ohio State University

Before attempting to discuss what should be the qualifications and training for a teacher of mathematics to engineers it might be well to take a look at the things that are expected of such a teacher. In order to do this we must decide on what kind of mathematical training we want our engineering students to have; what things in that training we want emphasized; whether or not there is a preponderance of opinion in favor of one procedure over another; and finally, determine whether the things we are proposing are new or have been problems since the beginning of engineering education.

Apparently the question of what information is most useful to an engineer is as old as engineering itself, for we find in the introduction to Book VIII of the Collection of Pappus the following paragraph which was written about 300 A.D.:

> Now indeed those who follow Hero carefully, think that one part of mechanics has to do with mathematical demonstration, and the other with manual work, and in the first part, which they call logical, they think that geometry, arithmetic, astronomy, and theoretical physics are involved, but in the other part, which requires manual labor, they think that the arts of working in iron and bronze and wood, painting and building, and those things which are involved in work with the hands, are to be sought. And whoever from an early age will think over this thing in his studies, and will become skilled in these arts, and has a varied talent, it is said that that one will be the best inventor of mechanical works (and an architect). But when it is not possible for the same person to comprehend thoroughly the complete mathematical theory, and to be learned in all the things of which we have spoken, those that have at their fingers ends anything whatever that practice requires in that line, so that they may apply it to any art at all, take precedence among those who wish to discuss a mechanical work.

We have here in this 1600-year-old document the two fundamental viewpoints which have not essentially changed with the passing of the years, namely the practical versus the theoretical. And the conclusion of Pappus that the individual who is thoroughly trained in mathematics so that he can apply it to any art at all will take precedence over all others is still fundamentally sound.

Coming to a later time we find Roger Bacon making this comment: "Mathematics is the gate and key of the sciences. Neglect of mathematics works injury to all knowledge, since he who is ignorant of it can not know the other sciences or the things of this world. And what is worse, men who are ignorant are unable to perceive their own ignorance and do not seek a remedy." While the poet Goethe exclained: "Mathematics opens the fountain of all thought!"

These two quotations seem to indicate that mathematics in the minds of these men is primarily a way of thinking about things and that if one stop developing that way of thinking, the whole scientific world will thereby suffer.

Do we want our students of engineering taught mathematics from this viewpoint? If not what viewpoint should he adopt? In order to answer these questions we will be obliged to set up a list of objectives we want attained. Such a list was recently adopted by a committee of the faculty of the College of Engineering at Ohio State University. It reads as follows:

Objectives in courses in mathematics for engineers:

1. Give an introduction to mathematics as the language of science and lay the foundation for the reading of books involving higher mathematics.
2. Make such applications of the fundamental principles as may profitably be done at any given time.
3. Give sufficient familiarity with the mathematical processes to enable the student to formulate and solve problems arising in his future work as an engineer.
4. Show how the use of a few mathematical processes enables one to solve a wide variety of problems with the utmost economy of thought and labor.

The entire committee agreed that every one of the above objectives was essential, but the members disagreed somewhat on the emphasis that should be placed on each of the four items. The preponderance of opinion in the committee was that number three should be placed first in importance and that number one should be the final ideal to be striven for but probably never reached. However, in a recent questionnaire sent to the members of the faculty of the College of Engineering at Ohio State University, quite a number stated that the study of mathematics should mean more than merely the ability to solve a specific set of problems no matter how important that set might be. In fact, almost 50 per cent of the replies to that questionnaire were not favorable to teaching the subject as a tool subject, while about 90 per cent stated that mathematics should be taught as a method of thinking about things, and 4 out of 65 believed that mathematics should be taught purely as a cultural subject.

And now, having compiled some evidence that the problem of mathematical training for engineers is not new; that there has always been a difference of opinion regarding the type of training necessary, and having set up a list of objectives, let us take a look at the qualifications of the man we expect to do the job of teaching so that these objectives may be attained.

First, I would say that he must have an unbounded love and enthusiasm for his subject from two points of view: (*a*) because of the beauty and universality of its methods; (*b*) because of its usefulness when attacking practical problems.

Now I know that in placing this as the first of my qualifications I am running counter to the prevailing opinion that we are not teaching subjects, but are training people and that their likes and dislikes must be sympathetically studied. But in the face of this opinion I have deliberately done what I have done. Moreover I believe I am right in placing this qualification first. My reason for so doing is quite obvious. Because I believe that no one can

successfully teach anything in which he is not tremendously interested, no matter how much sympathy he may have for his students.

Moreover, if the instructor thoroughly believes that he has in his possession a wonderful tool, both beautiful to contemplate and useful in the humdrum things of life, why shouldn't he be enthusiastic about it and, being enthusiastic, be eager to sell that tool to any who may come under his influence?

This brings me to my second point. Namely, that this instructor should possess the qualities of a salesman. This necessitates two things: (*a*) a knowledge of the future possible needs of the student; (*b*) the usefulness of mathematics in satisfying those needs.

Now, the needs envisaged by the instructor may not be apparent to the student, any more than my need for an airplane may be apparent to me, but the instructor who is enthusiastic, who is willing and able to make the proper demonstrations of his wares may make the student desire to have more mathematics by showing him its value to him in his daily work as an individual, just as a good salesman may talk me into the notion of buying an airplane by showing me how I can use it to advantage in my business.

But enthusiasm and salesmanship are not sufficient qualifications for this instructor about whom I am thinking. He must be a master of his subject and have a broad knowledge of its applications in other fields. Moreover, he must be sympathetic and patient in the face of ignorance and prejudice. He must be appreciative of the difficulties of his students and possess a sincere desire to help them overcome those difficulties. He must also be thoroughly familiar with the viewpoints of successful engineers regarding mathematics and the place it should occupy in an engineering education. Above all he should not be dogmatic and ignore other viewpoints, for such dogmatism will defeat any amount of enthusiasm.

What kind of training should such an instructor have? He should have (1) a thorough training in mathematics; (2) a broad training in pure science; (3) some training in the practical applications of mathematics to industry. This training is essentially mathematical and scientific and not necessarily the training given to the engineer. I am not sure that the successful engineer with engineering training and background would make a good teacher of mathematics. In the first place, he probably would be more interested in engineering than in mathematics. Moreover, he might have a tendency to emphasize the particular kind of engineering in which he happened to be interested. Then the simple fact that he was trained as an engineer shows that primarily he is not interested in teaching and hence would not be as successful as one who was primarily interested in teaching as a profession. In an

article in the May, 1934, issue of the Journal of Engineering Education, Dean Butler of the Arizona School of Mines, in an article entitled "Should Engineering Teachers Practice Engineering?" voices this sentiment when he says that the successful engineer seldom cares to spend all his time teaching. And he had in mind the engineer who was teaching a technical engineering subject. The statement would certainly be more applicable to an engineer teaching mathematics.

And finally let me venture the remark that it would be reasonable to suppose that a teacher of mathematics to engineers should be primarily interested in mathematics. Otherwise, why would he want to teach it at all? That he should be interested in the applications of mathematics to practical problems goes without saying. But unless he is interested in Mathematics as the language of science, unless he is thoroughly aware of the fact that the symbolism used in mathematics is meaningless except for the precise meaning assigned to it in a particular problem, unless he is always conscious of the fact that symbolism is introduced in order to make for economy and clarity of thinking, his teaching of mathematics will fail to produce in the minds of his students that clarity of thought, preciseness of statement and keenness of interpretation so essential in all quantitative thinking.

STANDARDS FOR LABORATORY REPORTS

By ARTHUR L. ALBERT

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Training in the preparation of engineering reports is an important part of an engineering education. Practical instruction in report writing can best be given as an adjunct to actual laboratory work. Unfortunately, many engineering instructors give little attention to objectives and standards for laboratory reports, and their students, accordingly, obtain inadequate training in report writing. On the other hand, some instructors, especially those who have had contact with industrial organizations wherein many reports were prepared, may be overzealous, and their students are often overburdened with laboratory reports.

A few years ago conditions in the School of Engineering at Oregon State College were somewhat as just described. There existed little uniformity in the objectives and requirements for laboratory reports. A committee was appointed within the Engineering School to study the situation and to make recommendations to the engineering faculty. As a result of these studies, many interesting and helpful suggestions for improving student laboratory reports have been made.

For the purpose of this paper, a formal report is one which is complete in every essential detail, and one which is prepared in accordance with the highest engineering standards of clearness, accuracy, and neatness.

It is not best to require all students to follow the same rigid outline in preparing all reports. It is, however, desirable to suggest a somewhat flexible outline which will be followed in the preparation of most reports, especially those which are formal. Such an outline is, of course, most useful when the students are first becoming experienced in engineering report writing, as in the sophomore and junior laboratory courses.

Regarding an outline for reports, at least two possibilities exist. First, each instructor, or each department or engineering school, may design an arbitrary and somewhat academic outline for reports. Second, it is possible to follow the outlines suggested by the national engineering societies for use in the preparation of papers for presentation and publication in the technical journals. For example, the American Institute of Electrical Engineers issues

a pamphlet in which rules and other important information for the preparation of technical papers are included. This second method is by far the better.

An examination of the suggestions of the professional societies reveals that the general forms of the outlines and other requirements are much the same. The following outline and suggestions are very similar to those of the national societies and are, accordingly, recommended for use by engineering students for preparing laboratory reports. It is especially desirable that they closely conform to these requirements until they have learned the essentials of good report writing. After these details have been mastered, it is, of course, important that each student be encouraged to develop a style of his own.

Suggested Outline

Introduction

This should briefly show the relation of the experiment to the general subject under study, explaining the object or purpose of the investigation. It should not be long or burdensome.

Theoretical Considerations

Where considerable theory is involved, it should be discussed under this heading.

Procedure or Method

This should describe the apparatus used and should explain how the experiment was performed. Where a detailed list of equipment is advisable, such information should be included in an appendix.

Discussion of Results

In general, experimental data, descriptive curves, and diagrams (when not presenting detailed information and when not burdensome so as to destroy the effectiveness of the report) should be included in this part of the report, much as in a technical paper. Where data, curves, or diagrams are numerous or detailed, they should be included in an appendix. References to, or quotations from technical literature should be made as in writing technical articles. ***Conclusions should be drawn*** in this part of the report.

Conclusions

This part should consist of concise statements of the conclusions drawn in the preceding section. It may well be a numbered list.

Bibliography

This should be a list of the works consulted and referred to in the main body of the report, rather than an unrelated list of books and articles in the general field.

Appendix

This part may often be omitted. The appendix should not be regarded as a place for including unrelated or uncoordinated information. Material in an appendix should be referred to in the main body of the report. Curves, diagrams, data, or other information which may be burdensome in other parts of the report may be placed in an appendix.

If engineering students are to prepare satisfactory reports, it is necessary that they have the proper mental attitude toward this work. It is desirable to point out to the students the importance of reports in engineering practice, and that because of this, reports are required and high-quality work is insisted upon. It is advisable in most instances to have the report written from the standpoint of an engineer submitting the results of an investigation to his supervisor, rather than as a student reporting a routine experiment to his instructor. Following the suggestions of the professional societies assists in making this possible. This point is well illustrated by the often-repeated student query, "What do you want in this report?"

It is especially important that engineering students be taught to use these important tools most effectively. The preparation of laboratory reports offers an excellent opportunity for developing this phase of engineering training.

Standard graphical symbols approved by the American Standards Association or issued by the professional engineering societies should be followed in the preparation of reports. Such symbols should be introduced to students in their drawing courses, and can be effectively used there for practice work. Certain portions of these standard graphical symbols which apply in each particular branch of engineering should be reproduced and made available to the students majoring in that particular field. Furthermore, the instructors should insist that the students use these symbols in all their work.

Care should be taken to insure that curves are prepared in accordance with good engineering standards, and the following suggestions are helpful in achieving this.

Students should be required to draw curves on a good grade of coordinate paper. Centimeter coordinate paper has been found

much more convenient for some work than paper having major divisions in inches. Only black drawing ink should be used. If inks of various colors are employed, students depend on color instead of symbols, arrangements, and titles to distinguish the different curves. This may result in confusion if curves are blue printed or otherwise reproduced. Smooth curves should be drawn, except in rare instances where the nature of the data is such as to justify an irregular curve. Too often students feel that the curve must pass through each point obtained when the data are plotted.

When plotting curves, a very strong tendency exists to choose a scale as large as possible. Such a choice frequently results in curves which are distorted and in which experimental errors are greatly magnified. The scales for many curves should start at zero, so that the curves can be extended to zero to observe conditions below the values of data actually taken. This is especially important where the purpose of the data is to illustrate basic principles.

The appearance of many curves is made very poor by the symbols used to represent the values or points of the data taken. Of course, it is sometimes necessary to use various symbols, but in general, very small circles *drawn with instruments* will suffice. The appearance of these will be much better than the many different free-hand symbols sometimes used, and this will usually justify the additional effort required. Several types of well-appearing symbols can be developed from small circles; for instance, a circle with the center filled in, or a circle with a line across the center. Where a point falls some distance from the curve, and confusion may result, a small arrow or line can be used to indicate the curve to which the point belongs.

One of the most common and serious errors in curve plotting is the omission of the information describing the equipment under test. Each curve sheet should include a short descriptive title. Also, all information, such as the manufacturer, type, rating, serial number, and other important data on the device tested should be included. If a name plate exists, it is well to transfer all this information to the curve. The curve sheet should be as complete as possible without the need for continual reference to other parts of the report. Each curve should be clearly labeled, and where several appear on the same sheet, it may be desirable to number the curves and include a descriptive table.

It is recognized that in many engineering offices, draftsmen prepare most of the drawings and curves from sketches or data supplied by the engineers. Some instructors may, accordingly, feel that such elaborate details as recommended in this paper are of

little value to engineering students. Nevertheless, many engineering graduates first serve as draftsmen, and it is possible that the percentage entering this type of work will increase in the future. It is important that the students master the principles and know good drawings and curves, even if they are seldom called on to do the actual work.

There are many good arguments in favor of preparing printed data sheets properly arranged with the column headings, etc. Also, there is much against this practice. In many laboratory courses, particularly those outside the major, printed forms may be advisable. Students should, however, obtain experience in preparing their own data sheets.

Probably the most important criticism of data sheets is that they contain too many data and too little information. Unless the students are carefully instructed, they seldom insert adequate column headings and often omit the units of measure; also, they often neglect to give satisfactory information regarding the device under test. The complete name plate data of the device or a machine under test should always be included. The practice of merely stating Part I, Part II, etc., as headings on the data sheet again illustrates the point that students should regard their laboratory work as an engineering investigation rather than as an academic study made in accordance with some outline the instructor may supply. The practice of taking data in the laboratory on scratch paper and later transferring the information to data sheets should be discouraged. This often results in serious omissions and errors.

It is scarcely necessary to add that for formal reports the data sheets should be carefully typed or prepared in ink. It may be deisrable to include the original data sheets in the back of the report for reference in case of errors.

Many instructors do not realize the amount of work students do in preparing a complete laboratory report. Studies have shown that from ten to fifteen hours are required to prepare an *average* report following the suggestions given in this paper. It is apparent, therefore, that the students should be expected to submit a maximum of only three or four complete or formal reports during a term. If more than about this number are required, the students will be overworked and will be actually earning more credit hours than are received. Investigations have disclosed that in courses requiring seven or eight complete reports each term, the students were actually earning about *twice* as many credit hours as the course carried.

Estimates made by students have disclosed that of the ten to

fifteen hours required for the average report, about *one-half* of this time was spent on purely routine work such as typing, from which the students derived little benefit. Also, studies have shown that although laboratory instructors may feel that their work is of extreme importance in presenting engineering fundamentals, the students are of no such united opinion. As a matter of fact, the students reported such a wide divergence of views it was concluded that the relative importance of laboratory work, lectures, and computation periods in presenting fundamentals depended largely on *who was in charge of the work*, and on *who was receiving the instruction*.

For the most efficient teaching, each report should be promptly prepared and handed to the instructor without delay. If this is done, the instructor should immediately correct the report and return it to the students. They desire to have errors noted and grades recorded on their reports and want the reports returned at once so that they will not make similar errors in subsequent reports. Graduate students can be of great assistance in correcting routine errors in reports.

Although many arguments such as "This is a major course" are presented, there is no real justification for overburdening students with reports. On the other hand, all engineering students should be carefully trained in report writing. When a complete or formal report is requested, it should be prepared in accordance with the highest engineering standards. It seems best, therefore, to require only a few formal reports each term. For the other experiments, informal reports consisting only of curves, or only of computed data sheets, or whatever the instructor feels will be adequate, should be prepared. It may be the best policy to require formal reports in the major courses only; that is, a student majoring in mechanical engineering should not be asked to prepare formal reports in the electrical courses he is required to take.

In some instances, a letter of transmittal including curves and data sheets, such as is often prepared in practice, will suffice for an informal report. The experience in letter writing will be of great value to the students, and many need it badly.

In conclusion, therefore, it is evident that for effective teaching, laboratory report objectives, standards, and related requirements, should receive careful attention. High engineering standards should be maintained and care used to assure that the students are adequately trained in this important work, even if this sacrifices quantity of reports for quality. In other words, *fewer* and *better* reports is the need of many laboratory courses.

NEW MEMBERS

ADENDORFF, JOHN, Professor of Industrial Engineering, University of Akron, Akron, Ohio. F. S. Griffin, W. A. Gilmore.

ANDERSON, PAUL, Instructor in Structural Engineering, University of Minnesota, Mirneapolis, Minn. A. S. Cutter, O. M. Leland.

ANDREWS, STEPHEN C., Instructor in Industrial Engineering, Virginia Polytechnic Institute, Blacksburg, Va. P. T. Norton, E. B. Norris.

AYRES, EDMUND D., Assistant Professor of Electrical and of Steam and Gas Engineering, University of Wisconsin, Madison, Wis. Ed. Bennett, J. W. Watson.

BRECKENRIDGE, ROBERT W., Instructor in Mechanical Engineering, Iowa State College, Ames, Iowa. H. J. Gilkey, W. H. Meeker.

BURRIS-MEYER, HAROLD, Assistant Professor of Humanities, Stevens Institute of Technology, Hoboken, N. J. F. C. Stockwell, F. D. Furman.

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CAMPBELL, JOSEPH W., Assistant Professor of Metallurgy, Purdue University, Lafayette, Ind. F. L. Serviss, A. P. Poorman.

CARMICHAEL, COLIN, Assistant Professor of Mechanical Engineering, University of North Carolina, Chapel Hill, N. C. E. G. Hoefer, T. F. Hickerson.

CHILD, ALFRED T., Associate Professor of Chemical Engineering, Rose Polytechnic Institute, Terre Haute, Ind. John White, C. C. Knipmyer.

CREESE, JAMES, Vice President and Treasurer, Stevens Institute of Technology, Hoboken, N. J. F. C. Stockwell, F. D. Furman.

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KEATON, L. D., Assistant Professor of Industrial Education, East Texas State Teachers College, Commerce, Texas. H. M. McCully, F. L. Bishop.

KINNEY, E. E., Assistant Professor of Electrical Engineering, Michigan State College, East Lansing, Mich. Re-instatement.

KULP, MARK R., Assistant Professor of Agricultural Engineering, University of Idaho, Moscow, Ida. I. C. Crawford, R. H. Hull.

LADNER, A. COLLINS, Assistant Professor of Mathematics and Engineering Science, Denison University, Granville, Ohio. B. D. Greenshields, W. C. Ebaugh.

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NARMORE, PHIL B., Assistant Professor of Engineering Drawing and Mechanics, Georgia School of Technology, Atlanta, Ga. R. L. Sweigert, J. E. McDaniel.

NEWING, RALPH L., Manager, International Textbook Co. (Educational Dept.), Scranton, Pa. G. W. Farnham, L. P. Arduser.

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THOMAS, MELVIN A., Professor and Head, Department of Electrical Engineering, New Mexico College of A. & M. Arts, State College, N. Mex. D. B. Jett, J. A. Correll.

VOTH, JOHN J., Assistant Professor of Industrial Arts, Bethel College, Newton, Kansas. F. L. Bishop, Nell McKenry.

WEBER, ERNST, Research Professor of Electrical Engineering, Brooklyn Polytechnic Institute, Brooklyn, N. Y. E. J. Streubel, H. P. Hammond.

WESTON, ARTHUR J., Chairman, Department of Humanities, Stevens Institute of Technology, Hoboken, N. J. F. C. Stockwell, F. D. Furman.

The engineering colleges of Alabama, Virginia, Louisiana, Florida, South Carolina, North Carolina, Mississippi, Tennessee, West Virginia, Kentucky and Georgia petition the establishment of the SOUTHEASTERN SECTION of the S.P.E.E.

(Council has approved the formation of this Section.)

FLOYD FIELD, *Chairman.*

COLLEGE NOTES

Clemson College.—The Engineering curriculum has been revised, effective this year, to strengthen the professional aspect of the courses and to make available a wider range of general cultural elective work. Shop work has been placed earlier in the course and reduced in some cases. Emphasis, as in the past, will be on the educational value of shop work rather than on training for craftmanship.

Several changes have been made in the teaching staff. J. H. Sams, Assistant Professor of Mechanical Engineering, on leave of absence, is teaching in the same capacity, at the University of Michigan. C. H. Topping, Purdue '30, has a temporary appointment as Assistant Professor of Mechanical Engineering to carry on Mr. Sams' work. Mr. Topping was formerly with Sargent and Lundy, Consulting Engineers, in Chicago. A. B. Credle, Cornell '30, M.S. '31, has been appointed Assistant Professor of Electrical Engineering. Mr. Credle has been Graduate Assistant at Cornell, has had practical experience in high tension work and is a licensed radio operator, first class. G. M. Carter, Clemson College '34, is Student Assistant in Drawing and Shop. C. P. Philpot has been transferred from Instructor in Electrical and Mechanical Engineering to Assistant Professor in charge of Forge and Foundry.

Enrollment figures for Clemson show an increase of seven per cent for engineering and 11 per cent for the whole college, with over 50 per cent increase in freshman from a year ago.

New appointments to the Faculty Staff of **Columbia University** are: Armstrong, E. H., E.E., Columbia, 1913, M.S. (Hon.), Columbia, 1929, Professor of Electrical Engineering. Harness, George T., B.S., 1928; M.S., 1929; Ph.D., California Tech, 1933, Instructor in Electrical Engineering. Johnston Bruce, B.S., Illinois, 1930; M.S., Lehigh, 1934, Instructor in Civil Engineering. Matzke, Arthur E., A.B., Columbia, 1928; B.S., 1929; C.E., 1932, Research Assistant in Civil Engineering. Oakey, John A., B.S., Wisconsin, 1929; M.S., 1933, Instructor in Civil Engineering. Sanborn, James F., B.S., Harvard, 1899, Associate Professor of Civil Engineering. Soule, Roland P., B.S., Rochester, 1917; Chem.E., Columbia, 1920; A.M., 1921; Ph.D., 1922, Lecturer in Chemical Engineering. Thomas William D., Jr., B.S., Pennsylvania State, 1934, Assistant in Chemical Engineering.

Representative of Tau Beta Pi, honorary engineering society with chapters located in sixty-five engineering schools throughout the United States, gathered on the Columbia campus on October 11th to 13th for the thirty-third annual convention.

Tau Beta Pi is a national society and has a membership of over 20,000 engineering students. The Columbia Alpha chapter together with chapters at Brooklyn Polytechnic, Stevens and N. Y. U. acted as host to the convention.

The method of charging at the rate of $10.00 per course point has been abandoned. Effective this September a flat fee of $400 for the year has been instituted. In addition there is a breakage deposit of $25 which must be maintained at all times.

The Board of Overseers of **Harvard University** at its last meeting approved action previously taken by the corporation providing a plan of reorganization of instruction in engineering in the University. This plan, which will become effective in 1935–36, provides that undergraduate instruction in engineering will no longer be given in the Engineering School but will thereafter be undertaken solely by the Division of Engineering Sciences in the College, although with the same equipment and under the same officers of instruction as formerly.

The tendency in recent years has been for the majority of students wishing to obtain undergraduate instruction in engineering at Harvard to secure it through the Division of Engineering Sciences in the College rather than by registering as undergraduates in the Engineering School, and the administrative change now to be made is in conformance with this tendency.

The Engineering School will be continued on a strictly graduate basis, as the Graduate School of Engineering, with courses in the several branches of engineering leading to the degrees of Master of Science in Engineering and Doctor of Science.

As instruction in engineering in Harvard University is so intimately involved with the terms of the Gordon McKay Endowment, the plan of reorganization has been submitted to the Trustees of the estate of Gordon McKay who, with the advice of counsel, have assented to and approved of it.

Michigan College of Mining and Technology.—Continuation of the mineral-resources research at Michigan Tech under an FERA grant began October 12 with approximately 125 persons engaged. Fifty per cent of available funds for this program must be expended for labor from relief rolls. During the first three months of the project, from June to September, 104 persons were employed.

Most of the summer's investigations are being continued, among them those into the utilization of low-grade iron ores, into copper in cast iron, and into the lowering of copper milling costs through a method of selecting from mined material a definite portion containing practically all the copper. Other studies carried over from the first quarter include an examination of steam as compared with electrical mine hoists, tests on automobile commutators of various materials, and geophysical research. By September 1 the electrical engineering department had determined the fact that silver-bearing copper is better than non-argentiferous in commutators. The electrical staff is now expanding this study, with stress on detailed quantitative comparisons of the two types of copper. This fall and winter the geophysical staff of the college will supervise the calculation and correlation of the data taken by them this summer and will begin its interpretation, as well as continuing the field work while weather permits.

The initiation of the foregoing FERA projects and of additional ones conducted by other departments required the official approval of several governmental agencies, among them the Michigan State planning board, of which Professor A. T. Sweet of Michigan Tech is a member as chairman of the mineral-resources sub-committee. This sub-committee includes President W. O. Hotchkiss and Drs. James Fisher and T. M. Broderick of this faculty. J. L. Byers of the metallurgy staff is assisting Professor Sweet.

An important FERA accomplishment in Michigan, the establishment this fall of FERA Freshman Colleges, has entailed the cooperation of this institution as well as of three normal schools. Michigan Tech has general supervision over six of the Freshman Colleges. One of them, a combination of what were originally scheduled to be four separate institutions, is housed in Michigan Tech buildings and its students have been granted, by the Michigan Tech student organization, certain campus and clubhouse privileges ordinarily reserved for regular M. C. M. T. undergraduates.

The college committee in charge of the six Freshman Colleges is composed of Dr. James Fisher; Professor L. F. Duggan, registrar; and Dr. E. L. Wood. These three faculty members also are the supervisors of all Freshman College courses in mathematics, physics, geography, English, and foreign languages. Other faculty members exercise general direction over Freshman College courses in chemistry, shops, drawing, and history.

The teaching staffs of our Freshman Colleges are chosen largely from unemployed teachers and other qualified persons throughout the Copper Country. The lists are provided by the Houghton County relief commission. A few sections in the Freshman Col-

lege that is housed on the Tech campus are taught directly by Tech instructors, with relief employees as assistants and readers.

Promotions announced this autumn are as follows: Annette Sibilsky, formerly assistant to the president and the treasurer, adds the post of assistant treasurer; R. W. Drier has been raised from assistant professor to associate professor of metallurgy in charge of roentgenology; L. W. Eastwood has been raised from instructor to assistant professor in metallurgy; and Harold Walker, Ray Smith, and Ray Marcotte have been raised from assistants to instructors in metallurgy.

Professor Drier along with his departmental colleague, Professor C. T. Eddy, was awarded the Ph.D. degree at the June graduation exercises. At that time, also, Professor James Fisher was granted the honorary degree of Doctor of Science in recognition of his forty years of service to the college. Dr. Fisher is particularly noted as director of the geophysical investigations conducted by the M. C. M. T. during the past six years.

Our enrollment at the **University of Nebraska** has increased perceptibly this fall. The maximum change occurs in the freshman year.

Professor Linus Burr Smith, formerly of Kansas State College, begins work with us this fall as Chairman of the Department of Architecture. He succeeds Professor Harry Francis Cunningham, resigned. Professor Smith is a graduate of Kansas State College, with a Master's degree in Architecture from Massachusetts Institute of Technology. He is an experienced teacher, especially in History of Architecture and in Architectural Design. He is also an artist in the field of water color.

Worcester Polytechnic Institute.—The curriculum of every department of the Institute has recently received much study and consideration with the result that many changes have already been put into force or are planned for the near future. We are now beginning upon a transition period which will last for a number of years. The movement is toward more freedom of choice for the student in his program of study. Course dealings with the history of civilization and the development of science and engineering have been introduced and may be chosen instead of courses in modern languages in the freshman and sophomore years. The courses in economics, government, and business have been increased and are now a requirement throughout the entire junior and senior years. The curricula of the various engineering departments have been revised and overhauled and new courses added, thus increasing the number of electives.

The division of Heat-Power Engineering in the Mechanical Engineering Department is being reorganized under Professor Gustaf A. Gaffert who returns to the Institute, after an absence of several years. He was graduated in 1923. In the interim, in addition to other experience, he served on the staff at the University of Illinois and with the Sargent & Lundy Company, consulting engineers. More recently he has been studying at the University of Michigan where he has completed work for the D.Sc. degree. The new program is being designed to coördinate more efficiently the teaching of thermodynamics, steam engineering, air and gas engineering. More work will be given in the allied branches of heating and ventilating, air conditioning, and refrigeration.

Dr. George H. Haynes resumes his duties this year as Head of the Department of Economics and Government after a leave of absence spent in research at the Congressional Library, Washington, D. C.

Mr. S. H. Fillion returned to the Civil Engineering Department after a year of study at the University of Michigan. He is offering a new course in Geology this year.

Dr. R. A. Beth of the Physics Department is on a leave of absence at Princeton University where he is Research Associate for the year.

SUGGESTIONS FOR RESEARCH PROJECTS

With the object of stimulating interest in research work, the Committee on Research of the Institute has collected from electrical engineers in the industry suggestions for research projects suitable for advanced or graduate students and others in the engineering schools who are desirous of undertaking some kind of research work in the electrical engineering field.

A first list of over 100 such research suggestions in 12 branches of electrical engineering has been assembled. A widely varying range of experimental facilities is involved, from the simplest equipment found in any electrical laboratory to highly special facilities which would be available only in a very comprehensively equipped laboratory.

Copies of this list in mimeographed form may be obtained by any member of the teaching staff of an engineering school by merely addressing a request for a copy (or copies) to the Committee on Research, American Institute of Electrical Engineers, 29 West 39th St., New York, N. Y.

SECTIONS AND BRANCHES

The Spring Meeting of the **Pennsylvania State College Branch** of the Society was held at 8:00 o'clock, Wednesday evening, May 23, 1934, in Room 107, Main Engineering. Thirty-five members and guests were present.

Professor L. S. Rhodes, President, presided and opened the meeting with a few introductory remarks.

The minutes of the reorganization meeting held on December 13, 1933, were read by the Secretary and approved as read.

Professor R. B. Nesbitt spoke on "New Ideas in Engineering Education." He prefaced his remarks by calling attention to a paper in the November, 1933, JOURNAL OF ENGINEERING EDUCATION by Professor R. L. Sweigert on this same subject. Professor Nesbitt said that he had tried a new method of teaching in a course of his for Seniors with good results. The method consists of giving the students no textbook but an outline with references. This outline is checked up by written questions, a term paper, and oral tests or conferences. The student is put on his own, but guided by his instructor. This method puts the emphasis on the students learning rather than on the instructor teaching. Among those taking part in the discussion which followed were Professors Thayer, Rhodes, Powell, Sackett, Walker, Govier, Stavely, and Everett. This discussion centered around the proper courses to which this method could be applied, and the time question both for the student and the instructor. Several of the speakers stated that they used parts of this method in their courses with Seniors and Graduates and with some success.

Professor Doggett, the next speaker, took as his subject: "Are There Too Many Engineers?" This was in the nature of a report of a Committee appointed by Dean Sackett and headed by Professor Doggett to investigate the challenge contained in a paper by Mr. Fiske in the January issue of *Civil Engineering*. In general Mr. Fiske's article claimed that there were too many engineers and that the engineering schools could stop graduating men because there were no places for them in industry for a long time. He based his claim on the census report. Professor Doggett's committee, after a study of the Penn State graduates in engineering to date, stated that there are not too many engineers, and that there are plenty of places in industry and elsewhere for new graduates. They believe that the census report's definition of an engineer is too narrow, and that it does not take into account the breadth of

engineering training. They found that for each five graduates in engineering, two are in strictly engineering or technical work (the census taker's engineer), two are in engineering work but of an administrative nature, and one is in another field, principally, business, banking, the law, etc.

"New Ideas in Hydraulic Instruction" by Professor L. S. Rhodes was next on the program. Professor Rhodes told of the good results achieved in rearranging the material in a course in hydraulics. The fundamentals of the course are taught in the first half of the semester, and then repeated in the second half for emphasis and elaboration.

Professor A. E. Neyhart next gave a talk on a "Study of Correlation Coefficients." He has been working on the correlation of the achievement of engineering students in Drawing, Mathematics, Physics, Chemistry, etc., and their success as measured by graduation. The Pearson product moment method was used in calculating these correlation coefficients, and was applied to the records of the students by departments, A.E., C.E., E.E., I.E., M.E., for the past five years. It was done for the subjects alone and also for combination of subjects. The correlation was good Professor Neyhart reported, although he emphasized that these correlation coefficients should not be taken too literally but only as an indication of probable success. Drawing in particular has a good correlation coefficient. Much discussion followed this talk. Among those taking part were Professors Walker, Everett, Duncan, McFarland, Thayer, Bullinger, and Sackett. The discussion centered about the actual values of these coefficients for particular subjects and for particular courses.

ALBERT P. POWELL, *Secretary.*

The fourth meeting of the **Purdue Branch** of the S. P. E. E. for the year 1933–34 was held in the lecture room of the Michael Golden Shops on the Purdue campus, Wednesday evening, May 9, 1934, at 8:15 P.M. The meeting, with Justus Rising of the Department of Practical Mechanics presiding, was attended by sixty-four persons.

Professor Rising appointed Professor W. E. Howland, Professor L. V. Ludy and Professor G. C. Blalock, members of the staff, as a nominating committee to furnish nominations for President and Secretary of the local branch at the first meeting of 1934–35.

The speaker of the evening, Dr. Clair V. Mann, Professor of Engineering Drawing and Descriptive Geometry, Missouri School of Mines and Metallurgy, Rolla, Missouri, was introduced by Professor Rising.

The topic of the address was "Objective Examinations in

Engineering Education." The address was thoroughly illustrated by slides and a full quota of exhibit materials in the form of case records and charts of tests of individual students as freshmen with the follow up record of later accomplishment in the engineering curriculum. Dr. Mann showed conclusive evidence of the very searching character of the objective type test as a method of measuring the aptitude of freshmen for engineering. Moreover in a very large majority of cases he stated that he found the reliability of his forecasts very high, the freshman high in aptitude and mental power proving to be high throughout his academic career. He cited occasional failure of the individual's interest as a reason for the rare failure of the prediction of the objective tests. As a counter-balance to the difficulty of preparing an objective type test for freshman drawing students Dr. Mann gave the facility of marking answer sheets. Dr. Mann stated that in his experience such tests strengthened the teachers interest in the individual student and enabled him to know each man with whom he came in contact.

Following the address the discussion brought out the fact that the objective type test has been used in engineering drawing at Purdue University and that Professor Justus Rising has designed a system for scoring these tests mechanically.

President E. C. Elliott of Purdue University suggested that the testing of students should be kept within such bounds that the teaching not be interrupted. He further pointed out that testing should include not only the determination of scholastic ability, but also the progress of the individual under instruction.

Dr. Mann replied that his objective tests were designed to serve as exercises in drawing as well as tests and that no additional time was required by the student for the express purpose of measurement.

The first meeting of the **Purdue Branch** of the S. P. E. E. for the year 1934–35 was held in the lecture room of the Michael Golden Shops on the Purdue campus, Monday evening, October 29, 1934, at 7:30 P.M. The meeting, with Justus Rising of the Department of Practical Mechanics presiding, was attended by forty-one persons.

At this meeting salient features of the forty-second annual meeting were discussed. The following persons spoke briefly:

Mr. J. N. Arnold, Practical Mechanics
Prof. D. D. Ewing, Electrical Engineering
Prof. C. F. Harding, Electrical Engineering
Prof. W. E. Howland, Civil Engineering
Prof. R. W. Lindley, Practical Mechanics
Prof. Justus Rising, Practical Mechanics

Prof. R. N. Shreve, Chemical Engineering
Prof. J. E. Walters, Personnel.

The discussion of the annual meeting proved as interesting to those who had been in attendance at Ithaca as to those who had not been there, since the annual meeting had been split, for several of its sessions, into small groups of members interested in specialized branches. Those who attended the annual meeting seemed to feel that the small groups divided on lines of interest promoted free discussion and resulted in a profitable session.

Professor F. L. Serviss of the School of Chemical Engineering was elected President of the Purdue Branch for 1934–35. Mr. D. S. Clark, of the School of Mechanical Engineering, was elected Secretary of the Purdue Branch for the same term.

Very truly yours,

W. I. FREEL,
Secretary, Purdue Branch of S. P. E. E.

A meeting was called at the **Georgia School of Technology,** on the recommendation of the representatives of the Engineering Colleges of the Southeast at a meeting held in connection with the National S. P. E. E. meeting at Ithaca, New York, June, 1934.

PROGRAM

November 9th—Friday

3 P.M.
Welcome by Dean D. P. Savant, Georgia Tech.
"Engineering Schools of the South, Past and Present,"
Dean Douglas Anderson, Tulane.
"Should the Engineering Course be Four or Five Years?"
Dean B. R. Van Leer, Florida.
"Entrance Requirements for Engineering,"
Dean C. R. Hixon, Auburn.

November 10th—Saturday

9 A.M.
Sections and Branches of S. P. E. E.
"Shall We Have One or Many for the Southeast?"
Dean W. C. Riddick, N. C. State College.
"What Should the Southeast Do to Have a Voice in Methods and Standards Set by the National S. P. E. E.?"
Prof. R. S. King, Georgia Tech.
"Engineering Degrees—Why, When, Where?"
Dean W. S. Rodman, Univ. of Virginia.
12 Noon—Adjourn.
2 P.M.—Football—Auburn and Georgia Tech.

DEAN FLOYD FIELD,
Chairman.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

Orientation: Two quite definite programs of orientation of freshman engineering students seem to be developing. One, carried on through "Freshman Week," is an attempt to make the new student at home in his college environment; the other, carried on by organized class work, is designed to get the freshman engineer acquainted with engineering as a profession. The "Freshman Week" undertaking seems to be accepted as a general college responsibility, but the responsibility for the second, or "professional orientation," program has not by any means been established. Most colleges have, however, delegated the job to a special organization, and the meetings of this section of the S. P. E. E. under the designation "Orientation of Freshmen" have been interesting and informative.

Without reflection on the excellent work now being accomplished by a number of outstanding leaders in this movement, the question might well be raised, before this program becomes too fixed to change easily, as to where, and in what environment, such work may most effectively be carried on. Certainly it must be surrounded by an *engineering* atmosphere; to be effective and most productive of the results desired it should be included in the course as early as possible; and it will be agreed that "orientation" should be a natural process.

The opportunity of the teacher of engineering drawing in the direction of orientation, therefore, becomes obvious. In the shoulder to shoulder conferences constantly a part of the method of instruction, in the atmosphere of the drafting room, and at the very beginning of engineering experience, an understanding and appreciation of engineering as a profession may well become a vital and deeply significant part of the work of engineering drawing teachers. Departments of Engineering Drawing may consider this an important additional educational service they are in a strategic position to render.

NECROLOGY

HAROLD DEWOLFE HATFIELD, Head of the Department of General Engineering of Rutgers University, died October thirteenth at the age of forty-six years. He was a native of Canada and a graduate of the Connecticut State College in 1910. While pursuing advanced studies in engineering at Cornell University he was called to Washington, D. C., in 1912, to organize and assume the deanship of the College of Applied Science at Howard University, in which were established the departments of Art, Architecture, Home Economics, and Civil, Electrical, and Mechanical Engineering. While in this position Mr. Hatfield received the degree, Mechanical Engineer, from The George Washington University, in 1915. From 1918 to 1922 he was vocational supervisor for the United States Veterans Bureau. In 1927 Mr. Hatfield became a member of the Society for the Promotion of Engineering Education. In 1929 he resigned the deanship at Howard University, after sixteen years of service at that institution, to accept the professorship of Industrial Engineering at Rutgers University. Two years later he was made Head of the Department of General Engineering at the same institution, which position he held at the time of his death. Mr. Hatfield was a natural educator, who had worked his way through college as a machinist and while still so engaged, found the opportunity to use his talents in helping others to follow in his footsteps. He had the rare gift of being able to form happy and mutually helpful contacts with all his students and as a testimony of student affection for his kindness to them, they voted him the most popular professor at Rutgers University, after he had been there but four years.

HARRY CREIGHTON PEFFER, Head of the School of Chemical Engineering, passed away July 17, 1934. He was born in Enon Valley, Pennsylvania, on August 15, 1873, and attended Pennsylvania State College from which he received the degree of B.S. in 1895 and M.S. in 1898.

His early industrial experience was with the Carnegie Steel Company, Pennsylvania Salt Company, and Aluminum Company of America. With the latter company as General Superintendent and Director of Research he was responsible for much of the pioneer work in the development of this valuable metal. During the

World War he had charge of explosive work for the United States government in West Virginia.

He came to Purdue in 1911 to organize the School of Chemical Engineering. The present school, one of the largest and most successful in the United States, is the result of his untiring efforts. Students, faculty and business associates alike respected this strong character, combining as he did excellent technical preparation with broad industrial experience, courage with fairness and a crowning sense of humor with interest in the well-being and happiness of his staff and associates.

The man is gone, but the monuments he has left behind will endure.

BOOK REVIEW

Review of Pre-College Mathematics. C. J. LAPP, F. B. KNIGHT, AND H. L. RIETZ. Chicago, Scott, Foresman and Company, 1934. 126 pages.

Those of us who teach mathematics or science to college freshmen are often troubled by students whose knowledge of arithmetic, algebra, and geometry is not what their high school credentials would lead us to expect. It is to help such students that this book has been written. It is the joint product of a professor of mathematics, a professor of physics, and a professor of educational psychology.

The authors state that the book has three specific uses: it offers (1) supplementary material for first year college courses in mathematics; (2) preparation for college courses in physics or chemistry; (3) a general review for high school seniors. The greater part of the book is devoted to arithmetic and algebra, and it affords a very satisfactory review of these subjects through quadratic equations and variation. About ten pages are devoted to some of the most important topics from geometry and trigonometry.

In connection with the study of radicals, on page 21, we find several examples of this sort: $\sqrt{49} = \pm 7$. The authors intend to convey the information that either $+7$ or -7 is a square root of 49; but the examples are misleading, because by general agreement the symbol $\sqrt{49}$ represents the positive square root only. The reviewer also objects to the statement, on page 111, that b'' is read "b double prime."

The book measures eight inches by ten and one half inches and is bound in stiff paper. Space is provided for the solutions of practically all of the problems, and the answers are given on perforated sheets. There is also a glossary of important words and phrases.

WM. I. MILLER

FINDING WORK

Mr. Samuel S. Board, placement specialist, of New York, writes in the November, 1934, issue of *Mechanical Engineering* on the subject of finding work. The story is 28 pages in length. The following remarks are a few of the outstanding suggestions which the reviewer feels will give the reader of this resumé some ideas about the important problem, that of finding work.

One distinguishing factor in the engineer's problem is the fact that he is so often employed by the job. This means, among other things, that the engineer must usually keep his eyes open for the next job. For this reason there is a real necessity for his attempting to work out an orderly method of advancement and for his learning the technique of selling his services when a change is necessary.

Essentially, the problem for the individual is the problem of salesmanship. He must determine the value and uses of what he has to offer. Then he must find a market.

Personal appearance being suitable cannot be overemphasized when one is preparing for the first interview. It is not suitable to apply for an office job looking like a tramp nor to ask for work on a relief project looking like a million dollars. You really must dress and act the part in applying for any job, and the first step is to appraise your usual appearance, your personal assets, and liabilities.

If you have been in a field of activity where you were producing tangible results why not turn to other operating fields. We are sometimes afraid of the bugaboo of specific experience. The engineer's impatience with human frailties seems to be the greatest limiting factor to his usefulness as an operating man.

Some engineers feel that they cannot sell because they think of selling as peddling, or as forcing on the buyer something he does not want and cannot use. True selling is almost the reverse and consists of so appreciating the problems, needs, and personality of the buyer as to be able to make him see, understand, and want the product being offered him. If it is not desirable and useful in a given situation, it should not be sold. If you are considering a selling job, remember that most worthwhile selling jobs to-day pay a salary or a salary plus a commission.

In planning a job compaign for yourself the first step is the preparation of a statement of your record in an intelligent, con-

cise, comprehensive order. Make the result a summary. In the first place it should contain a statement as to what you want to do, even if it has to be changed every time you apply for a different job. In the second place, it should contain a consecutive chronological experience record. Finally, such a record should include details of one's birth, education, family status, interests, and habits.

After you have decided where to apply for work remember that doing it in person is best—by letter if there is no other way. You must go after something *definite*, however. Do not just ask for a job. Tell your prospective employer that you wish to work for him and what you can do. Remember that you *have* something to sell—brains, experience, drive, enthusiasm, determination, even brawn, if necessary. Be not apologetic or ashamed but *sure* that you have something to offer.

You should, of course, be listed with your professional society. In replying to newspaper ads give information asked for, as briefly as possible. There are some good blind advertisements, but the chances are better if the firm's name and address are given. Blind ads are like blind dates—occasionally a "honey" but usually "sour."

The salary question is probably the most important. It is better to get the employer to make an offer which you can accept or try to raise if you think fit. If you *must* name a price, make it fit the job. After this has been done remember that in any event *you* terminate the interview. Too few people know when to do this all important thing. There is more danger of overselling than underselling. The second interview should not exceed twenty minutes in length.

Finally, let us bear in mind that a man's sureness of himself or his individuality distinguishes him from the rest of the herd. Such a man finds opportunity because he is remembered. Do people say about you, "What was the name of that man we saw last Friday?" or do they say, "Remember that man, Jones, we saw last Friday?" It's very much up to you; and your career, if not your happiness, may depend upon it.

R. C. GORHAM.